PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G02F 1/133, H04N 9/12 | A1

(11) International Publication Number: WO 91/08508

(43) International Publication Date: 13 June 1991 (13.06.91)

(21) International Application Number: PCT/GB90/01833

(22) International Filing Date: 26 November 1990 (26.11.90)

(30) Priority data:
8926547.4 24 November 1989 (24.11.89) GB
9001543.9 23 January 1990 (23.01.90) GB

(71) Applicant *(for all designated States except US)*: INNOVARE LIMITED [GB/GB]; Southpoint, 8 Paston Place, Brighton, East Sussex BN2 1HA (GB).

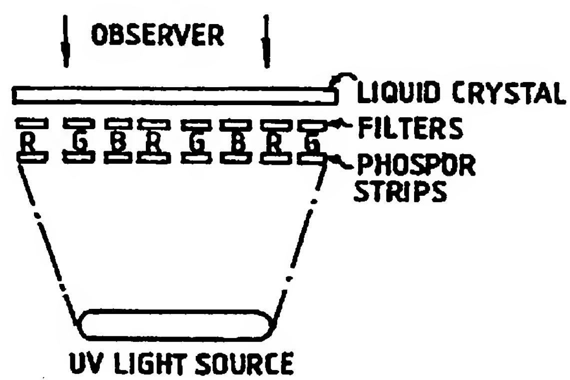
(72) Inventors; and
(75) Inventors/Applicants *(for US only)* : STONOR, John, Anthony [GB/GB]; SILSBY, Paul, Alistair [GB/GB]; Southpoint, 8 Paston Place, Brighton, East Sussex BN2 1HA (GB).

(74) Agent: STURT, Clifford, Mark; Marks & Clerk, 57-60 Lincoln's Inn Fields, London WC2A 3LS (GB).

(81) Designated States: AT, AT (European patent), AU, BB, BE (European patent), BF (OAPI patent), BG, BJ (OAPI patent), BR, CA, CF (OAPI patent), CG (OAPI patent), CH, CH (European patent), CM (OAPI patent), DE, DE (European patent), DK, DK (European patent), ES, ES (European patent), FI, FR (European patent), GA (OAPI patent), GB, GB (European patent), GR (European patent), HU, IT (European patent), JP, KP, KR, LK, LU, LU (European patent), MC, MG, ML (OAPI patent), MR (OAPI patent), MW, NL, NL (European patent), NO, RO, SD, SE, SE (European patent), SN (OAPI patent), SU, TD (OAPI patent), TG (OAPI patent), US.

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: A DISPLAY DEVICE



(57) Abstract

A display device comprising one or more sources of UV radiation (50); an LCD panel and two aligned tri-colour arrays. One array comprises filter elements (70) on one surface of the LCD panel, the other comprises phosphor elements (72) on the filter elements. The filter elements (70) each consist of one of three colour filters. The phosphor elements (72), when excited by UV radiation, each emit visible light in one of three colours. Filter and phosphor elements associated with the same colour are aligned with each other. The elements are preferably arranged so that ambient light falling on the front of the devices is at least partially reflected by the filters and/or phosphors. This can be achieved by controlling the spacing between filter and phosphor elements in relation to the width of an element. The arrangement can be used to provide a large scale colour display device comprising a plurality of modules (12).

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	FI	Finland	ML	Mali
AU	Australia	FR	France	MN	Mongolia
BB	Barbados	GA	Gabon	MR	Mauritania
BE	Belgium	GB	United Kingdom	MW	Malawi
BF	Burkina Faso	GN	Guinea	NL	Netherlands
BG	Bulgaria	GR	Greece	NO	Norway
BJ	Benin	HU	Hungary	PL	Poland
BR	Brazil	IT	Italy	RO	Romania
CA	Canada	JP	Japan	SD	Sudan
CF	Central African Republic	KP	Democratic People's Republic of Korea	SE	Sweden
CG	Congo	KR	Republic of Korea	SN	Senegal
CH	Switzerland	LI	Liechtenstein	SU	Soviet Union
CI	Côte d'Ivoire	LK	Sri Lanka	TD	Chad
CM	Cameroon	LU	Luxembourg	TG	Togo
DE	Germany	MC	Monaco	US	United States of America
DK	Denmark	MG	Madagascar		
ES	Spain				

A DISPLAY DEVICE

The present invention relates to a colour display device.

The display device of the present invention makes use of phosphors excited by a source of UV radiation with filtering of the phosphor output and image generation by the use of an LCD panel as an electro-optical shutter. This arrangement differs from common conventional arrangements because of its use of a UV source separate from the phosphors, in contrast to fluorescent tube type arrangements. A common conventional arrangement is illustrated in figure 1. Colour filters (red, green, blue) are provided on the face of the LCD panel opposite the fluorescent light sources. With such an arrangement only a small portion of the light generated by the fluorescent tubes is transmitted to an observer, a much larger portion of the input light is filtered out. This arrangement has been improved upon by the use of special fluorescent tubes which emit light in three narrow spectral bands, which correspond to the maximum transmission of the three colour filters. However, approximately two-thirds of the light from the tubes is still lost since all of the incident light is filtered by each of the three colour filter systems.

According to the present invention there is provided a colour display device comprising one or more sources of UV radiation; an LCD panel; a tri-colour array of filter elements with the filter elements each consisting of one of three colour filters; and a tri-colour phosphor array consisting of a plurality of phosphor elements each emitting, when excited by UV radiation, visible light of one of three colours with the corresponding colours of phosphor elements and filter elements being aligned with each other.

The present invention is such as to enable large scale colour displays typically of a size of between 1 and 10 sq.m. to be constructed readily and reliably. The invention is also applicable to small size displays.

Embodiments of the present invention will now be described by way of example only and with reference to the accompanying drawings in which:-

Figure 1 is a diagrammatic representation of a conventional colour LCD display device,

Figure 2 is a diagrammatic representation of a module of a display device in accordance with the present invention,

Figure 3 is a graph illustrating the wavelengths of the light emitted by the phosphor elements and the corresponding filter transmission wavelengths,

Figure 4 is diagrammatic representation of a large scale display device fabricated from a number of separate modules, in accordance with the present invention,

Figure 5 is a diagrammatic cross-section of a sealing strip to be inserted between the modules,

Figure 6 is a diagrammatic perspective view of a module housing,

Figure 7 represents a vertical section through the housing of Figure 6 with a screen component secured to the display surface thereof,

Figure 8 represents the flat arrangement of the remaining screen component and its associated circuit boards,

Figure 9 illustrates the components shown in Figure 8 when folded to match the configuration of the housing,

Figure 10 is a diagrammatic vertical section showing the

components in place on the housing, effectively being a combination of Figures 7 and 9,

Figure 11 is an enlarged diagrammatic section through the LCD panel shown in Figures 8 and 9,

Figure 12 is a plan view of the LCD panel shown in Figure 11,

Figure 13 is a diagrammatic vertical section through the filter and phosphor panel illustrated in Figure 7,

Figure 14 illustrates a back or underneath view of an assembled module, showing in particular the mechanical means for interconnecting modules,

Figure 15 is a side view of the back plate of the module.

Figure 16 is a diagrammatic sectional view of a display device according to the present invention suitable for use in a miniature television receiver.

Figure 17 is a diagrammatic sectional view of a component of a display device in accordance with the present invention,

Figure 18 is a view similar to that of figure 10 and

illustrating a variation of the internal structure of the module,

Figure 19 is a diagrammatic sectional view of an arrangement which enables the use of a phosphor binder to be avoided, and

Figure 20 illustrates a device for loading phosphor particles into channels in a plate.

One particular embodiment of the present invention is illustrated in figures 2-15 of the accompanying drawings.

The large scale colour display device 10 is formed from a plurality of modules 12. This is illustrated in figure 4. A typical large scale display may consist of one hundred and twenty eight modules arranged in a 4 x 32 matrix. The modules 12 are held, in a manner described hereinafter, closely adjacent each other. The columns of the modules are separated from each other by a rubber sealing member 14, the cross-section of which is shown in figure 5. The strips 14 are inserted between the modules subsequent to the mechanical interlocking of the modules.

Each module 12 is based on a housing 16 which has a configuration as illustrated in figure 6 and may, for

example, be formed of aluminium. The housing 16 comprises two side panels 18 joined together by end plates 20. End plates 20 each have the shape of a trapezium. Side plates 18 each have a respective flange 22 which projects outwardly to extend in the plane defined by the shorter edges of end plates 20. Housing 16 thus defines a trough shaped hollow enclosure, the large open surface of which will become the front of the display module. This surface may typically measure 400 mm x 100 mm.

The longitudinal edges of the front (or as illustrated, upper) edge of the housing 16 are provided with respective stepped shoulders 24 which provide keying for an adhesive 26 which is used to secure a number of screen components 28 to the front of the display module. The screen components 28 have the form of a square shaped plate and four such plates are located along the length of each housing 16. The plates are spaced from each other by a narrow strip of silicon rubber. Each screen component or plate 28 carries the filter and phosphor arrays and will be described in more detail hereinafter with reference to figure 13.

The remaining screen component of the display, essentially the LCD panel 30, is manufactured separately from the screen plate 28 and is subsequently bonded

thereto. The flat-plan arrangement of the LCD panel 30 and its associated components is shown in figure 8. The LCD panel 30 is basically the same shape and size as the screen plate 28. A vertical cross-section through the LCD panel 30 is illustrated in figure 11. The electrode pins 32 of panel 30 are connected to respective conductors 34 on a flexible strip connector 36. One such connector 36 is provided along each of two opposite sides of panel 30. They may be attached using known "thermal" conductive adhesives. Conductors 34 connect respective LCD electrode pins 32 to terminals 38 on printed circuit boards 40. Each printed circuit board 40 carries two LCD driver integrated circuits 42 which are interconnected between terminals 38 and a connector socket 44. That is, one connector socket 44 is provided on each circuit board 40. Each driver integrated circuit 42 has forty-eight outputs each of which is connected to a respective electrode pin 32 of the LCD panel 30. Thus, each LCD panel 30 comprises one hundred and ninety two pixels, as can be seen from the plan view of the panel 30 shown in figure 12. In practice, the smallest independently driven area is that associated with one driver circuit 42, i.e. one quarter of the LCD panel 30.

Figure 9 illustrates the configuration of the components shown in figure 8 when in place on housing 16. The

assembled module is illustrated, in vertical section, in figure 10. It will be apparent that the trapezium shape cross-section of housing 16 enables components 42 and 44 to be accommodated between the modules. In practice a small longitudinally spacing is left between adjacent modules. This spacing accommodates expansion of the modules with temperature and is preferably of the order of 1 mm. Horizontally the modules may be buffered from each other, e.g. by neoprene coatings on end plates 20. As indicated by reference numeral 46 in figure 10, a reflective coating is provided on the inner walls of housing 16. Figure 10 also indicates the module back-plate 48 which carries the UV lamps 50.

The basic arrangement of the display screen modules is shown in Figure 2.

A diagrammatic cross-section through LCD panel 30 is illustrated in figure 11. The relative dimensions have been grossly distorted for the purposes of illustration. Panel 30 essentially comprises two glass plates 52 and 54 with a liquid crystal material, preferably of the Twisted Nematic type, encapsulated therebetween. A matrix of transparent electrodes 58 is provided on the inner surface of glass plate 52 and a back-plane electrode 60 is provided on the inner surface of the glass plate 54. Along two edges of the panel 30,

glass plate 54 extends beyond plate 52 so as to provide ledges 62 which support the electrode pins 32. The glass plates 52 and 54 might typically have a thickness of 1mm with a separation therebetween, accommodating the liquid crystal material, of a few microns.

Where a Twisted Nematic material is used, respective linear polarisers 64 and 66 are provided on the front and rear surfaces of panel 30. Preferably, the polarisers are aligned in the same polarizing plane, to provide a so-called "negative" arrangement, i.e. dark when off. The polorisers may be formed of iodine doped long chain polymers and should preferably be of the low transmission type. Low transmission (38% or less) provides a significant improvement in contrast - higher contrast ratio. The materials and manufacturing techniques used to fabricate the panels 30 are otherwise essentially conventional and will therefore not be described in further detail. The illustrated panels provide an excellent angle of view of upto 140° or more.

Figure 13 is a diagrammatic representation of a section through screen component 28. Component 28 comprises a glass plate 68, the front surface of which supports an array of colour filters 70 and the rear face of which supports an array of colour phosphors 72. The arrays 70 and 72 consist of adjacent bands of red, green and blue

elements with the filter and phosphor elements aligned with each other by colour, red opposite red etc. Of course, the colours red, green and blue relate to the colours of the light concerned, that is the phosphor bands when excited by UV radiation emit red, green and blue light respectively. The phosphor emissions and corresponding filters are indicated on the wavelength graph of figure 3. The filters can be implemented by silk screening of appropriate inks. As indicated in figure 3, the filters are selected to have maximum transmission corresponding as closely as possible with the peak of the respective phosphor emission. Yttrium oxide: Europium can be used for the red phsophor, producing a peak emission at 611nm. Cerium Terbium Magnesium Aluminate: Tb: Ce can be used for the green phosphor, producing a peak emission at 545 nm. Barium Magnesium Aluminate: Europium can be used for the blue phosphor, producing a peak emission at 450nm. The materials and method of manufacturing the filter and phosphor arrays are otherwise essentially conventional and will therefore not be described in further detail herein. However, it should be noted that the phosphors will typically be applied to the glass plate 68 using a binder. Such a binder should be resistant to long term degradation caused by the UV light which is used to excite the phosphors. The UV lamps preferably have a radiation peak output at about 254nm.

It will be recalled that this embodiment of the present invention is concerned with large scale colour displays and that an important feature of this embodiment is that fact that ambient light passing through the LCD panel is at least partially reflected by the filters and/or phosphors. Such reflection enables a "dual mode" functionality to be achieved by the display device of this embodiment of the present invention. By "dual mode" is meant the following. The display modules can operate by the UV lamp 50 exciting the phosphors 72. Additionally or alternatively, in strong ambient lights the display can operate without the use of the UV lamp, as a result of the ambient light being reflected from the filters and/or phosphors. The effect is such that a high contrast saturated colour display can be provided even in strong sunlight. The requisite reflection is achieved by the absolute and relative dimensions of the components of plate 28.

The absolute and relative dimensions of the phosphor and filter elements which would be used to implement a display screen for a computer monitor or the like are such that the required reflection for dual mode operation would be absent. Such dual mode operation is not known to have previously been proposed for displays incorporating colour LCD panels. Clearly, there is a

range of values within which satisfactory reflection can be obtained so as to implement the dual mode operation of a large scale display device. Values within such ranges which have been found to achieve particularly satisfactorily results are: a band width of 2mm for the filter and phosphor strips with a separation between, that is the thickness of glass plate 68, of 1mm. It is the ratio of band width to phosphor/filter separation which is believed to be the more critical factor. As to absolute values, the dual mode operation appears to disappear rapidly as the width of the phosphor and filter elements decreases below 1mm. The required effect also appears to diminish rapidly as the thickness of glass plate 68 increases beyond 6mm.

To obtain maximum benefit from the dual mode operation a photosensor set with an appropriate threshold can be used to switch off the UV lamps when the ambient light is sufficiently high, and vice versa.

The rear face of each module is closed by a back-plate 48 which supports two UV lamps 50, as indicated in figures 10 and 15. The lamps 50 are held within the module and the external surface of back-plate 48 carries the associated starter and driving circuits 74, one associated with each lamp 50. Back-plate 48 also supports two further integrated circuits 76 associated

with the addressing of pixels in the LCD panels 30. Adjacent the top and bottom ends of each back-plate 48 are respective sockets 78 which are connected to integrated circuits 76 and from there to the integrated circuits 42 on each of the circuit boards 40. Sockets 78, and connectors 44, supply power and data to the LCD drivers and pixels.

As previously mentioned, direct drive of the LCD pixels is used in contrast to the conventional multiplex drive normally adopted for LCD panels. Thus, in the final display the modules may conveniently be grouped into sections for pixel addressing. For example, a display comprising one hundred and twenty eight modules may be split into eight sections each two modules deep and eight modules across - each section thus defining a display area of approximately 0.8sq.m. Serial drive signals for the LCD panels are applied to each section and the serial signals are daisy chained from one module to another within the section, via the connectors 78. The control signals are passed in serial form down to individual integrated circuits 42, at which point the serial information is converted to a parallel output and applied to the individual electrode pins 32. It is important to note that the direct drive of the LCD pixels enables grey scaling to be implemented within the LCD panels 30. Direct drive enables improved contrast

to be obtained. Also, individual parts of the displayed image can be updated without the need for a complete "refresh" of the whole display. The speed with which the display can be updated depends upon the characteristics of the LCD panels 30 - which will usually be temperature dependent. However, it has been found that a speed of 25 frames per second can be achieved at 50°C.

The mechanical interlinking of the modules to form the large display device will be explained with reference to figure 14. Each module is held in place with the adjacent modules by the use of square linking plates 80, a variation of the plates being used at the edges of the device. The square plates 80 carry an aperture in each corner through which the plate is screwed or bolted to a respective corner of the back-plate 48 of each module. A threaded aperture 82 is provided centrally in each plate 80. The purpose of the threaded aperture 82 is to receive a threaded support strut (not shown). The support struts can be used to secure the display in position, for example on the side of a building. The support struts can also extend between the modules and can be configured so as to provide additional rigidity to the matrix of display modules. Moreover, the support struts can project a short distance in front of the display modules (passing through strip 14) so as to

support a protective screen over the front of the display. A perspex sheet could be used for this purpose. Of course, the spacing between the screen and the front of the display should be as small as possible, and the material of the struts and their mode of connection to the screen should be carefully considered, to avoid degradation of the displayed image as viewed by the observer. Additionally or alternatively, an anti-reflection coating can be provided on the front of the display - either overall or on the separate LCD panels.

The embodiment described with reference to figures 2-15 of the drawings is concerned with a large scale, modular colour display. Various aspects of the invention are also applicable to displays which are neither necessarily large scale nor modular. For example, variations of components already described can be used in implementing a miniature, flat screen television receiver. A suitable arrangmenet is illustrated in figure 16.

In figure 16, the LCD panel 84 is of the Thin Film Transistor type with a respective poloriser 86 on each face of the panel. The tri-colour filters 88 are provided on a separate substrate which is placed in contact with the poloriser on the rear of the LCD

panel. In contact with the other face of the filter substrate is a fine mesh 90 of reflective material. The arrangement is completed by a tri-colour phosphor element 92 provided on a substrate 94 and a short-wave UV light source 96.

Substrate 94 is preferably formed of UV transparent glass or quartz with a transmissivity of the order of 80%. Phosphor element 92 may be in the form of 1mm tri-colour pixels coated onto substrate 94. The pixels may be in the form of spots or a matrix. Mesh 90 is preferably no thicker than 1mm. The mesh reduces scatter of light produced by the phosphors and also acts as a guide for ambient light passing through the LCD and reflected from the phosphors.

A mesh can also be used in the above described large scale display device.

The arrangements described have included a poloriser in contact with the rear surface of the LCD panel. The requirement for this poloriser can be avoided by providing the phosphors in crystaline form and aligning them to emit light in the required plane of polorisation. This can be achieved by growing phosphor crystals on a glass substrate or by growing the crystals in suspension and subsequently bonding them onto the

substrate.

Figure 17 illustrates a modified component which may beneficially be incorporated in a display device according to the present invention. The component is based on a moulded or machined substrate 98 of a material such as glass. The moulding or machining provides a grooved surface 100. A phosphor coating 102 is applied to the grooved surface 100. This has the advantge of considerably increasing the surface area on which the phosphor is coated. Reflective strips 104 are embedded in the opposite surface of the substrate and are aligned with respective ridges between the grooves of surface 100. These reflective strips act to guide light passing through the substrate. Typically, the substrate 98 might be of the order of 3mm deep, the groove 1mm deep and the reflective strips 2mm deep - for use in the embodiment of figures 2-15.

Some of the benefits of the component illustrated in figure 17 can be gained by use of a simple flat glass plate having parallel reflective strips embedded in and passing through the plate. The reflective strips should be aligned with the phosphor strips. Such an arrangement can, to some extent, obviate the criticality of the dimension ratios discussed above in achieving optimum results.

The quality of the display can be enhanced by careful consideration of the effective distribution of radiation from the UV source. Proximity of the UV source to the phosphors can present a difficulty since, typically the radiation will emenate from a narrow core within the tube. A simple expedient for achieving improved distribution is to abrade the surface of the UV tube. A more sophisticated solution is to introduce a separate diffuser. Of course, the closer the UV source to the phosphors and LCD, the greater the ultimate light output from the display device.

Another alternative for improving the distribution of radiation from the UV source is shown in figure 18. Figure 18 is similar to figure 10 but includes a "cold mirror" 106 and an associated heat sink 108. Mirror 106 is parabolic with the UV tube(s) 96 locates so as to optimise even distribution of the UV radiation. A plastics material is used to fabricate mirror 106. The characteristics of the material are such that heat generated by the UV tubes is transmitted to heat sink 108 instead of being reflected towards the phosphors and LCD, hence the designation "cold". Heat which is not travelling in the direction of heat sink 108 when it passes through mirror 106 is redirected by the matt black anodised aluminium casing 110. Mirror 106 will

absrob much less of the UV than diffraction grating or filter diffusers, thus providing improved efficiency.

Efficiency can also be improved by the use of a so-called "cold cathode" UV source. Such a source using a mercury/crypton mixture is beneficial.

It is possible to implement the present invention without using a binder to hold the phosphors in place. This is beneficial because some binders degrade rapidly when exposed to shortwave UV radiation. An advantageous arrangement is shown in figure 19. A quartz plate 112 and a glass plate 114 are each machined on one surface with complementary, rectangular section channels. One of the plates is placed with the machined surface uppermost. Phosphor particles are placed in the channels and the othr plate located in the first plate so as to sandwich the phosphor particles at the bottom of the channels of the first plate. The plates are bolted together and act as a high pressure clamp on the phosphor particles. A device for depositing phosphor particles in the channels is illustrated in figure 20. The device comprises a suction head 116 connected to a suction pump (not shown) by connector 118. Head 116 has a peripheral rim 120 within which phosphor particles are held by suction, when the head is placed in contact with a supply of particles. A membrane 122 prevents the

particles from entering connector 118. After loading with particles, device 116 is located over a channel and the suction released. The particles thus fall into the channel. Although illustrated as a "single channel" device, device 116 can readily be extended so as to load several channels - if not an entire plate - in one operation. Adjustment of the suction can be used to control the size of particle picked up by the device, thus performing a grading operation at the time of loading the channels.

Particularly for smaller sizes of display, machining of the plates with phosphor receiving channels can be difficult. As an alternative to machining the plates, one of the plates can be coated with a UV resistant material in which "channels" are subsequently etched. The phosphor particles are loaded in the manner described and the channels sealed by clamping of the other flat plate over them.

Polorisers used on the rear face of LCD panels in previous proposals can absorb and scatter as much as 50-60% of incident light. This problem can be mitigated by the use of layers of material such as melenex or glass to change the plane of polorisation of the light. Use of a Woolastone Prism can be particularly beneficial.

Finally, the colour range of the LCD panel can be improved either by varying the electrode voltage or by varying the duty cycle of the drive signals.

Embodiments of the invention have been described in detail with reference to the accompanying drawings. It will be readily apparent to a person skilled in the art that many modifications can be made and alternative embodiments implemented without departing from the scope of the inventive concept.

CLAIMS: -

1. A colour display device comprising one or more sources of UV radiation; an LCD panel, a tri-colour array of filter elements with the filter elements each consisting of one of three colour filters; and a tri-colour phosphor array consisting of a plurality of phosphor elements each emitting, when excited by UV radiation, visible light of one of three colours with the corresponding colours of phosphor elements and filter elements being aligned with each other.

2. A large scale colour display device having one or more sources of UV radiation and a plurality of modules each comprising: an LCD panel; a tri-colour array of filter elements adjacent one surface of the panel with the filter elements each consisting of one of three colour filters; a tri-colour phosphor array adjacent the filter array and consisting of a plurality of phosphor elements each emitting, when excited by UV radiation, visible light of one of three colours with the corresponding colours of phosphor elements and filter elements being aligned with each other; the arrangement being such that ambient light passing through the LCD panel is at least partially reflected by the filters and/or phosphors.

3. A display device as claimed in claim 2 wherein said elements are arranged side by side and the filter elements are spaced from the phosphor elements by a distance no greater than the width of individual elements.

4. A display device as claimed in claim 3 wherein the width of individual elements is at least twice said spacing distance.

5. A display device as claimed in claim 3 or claim 4 wherein the elements are arranged in opposite surfaces of a transparent panel, the filter elements on one surface and the phosphor elements on the other.

6. A display device as claimed in any one of claims 3 to 5 wherein the width of individual elements is at least 1 millimetre.

7. A display device as claimed in any one of claims 3 to 6 wherein the spacing distance is less than 6 millimetres.

8. A display device as claimed in any one of the preceding claims comprising means for driving the LCD panel, said driving means being arranged to drive

individual pixels of the panel directly.

9. A display device as claimed in claim 1, wherein the LCD panel is of the thin film transistor type.

10. A display device as claimed in claim 1, further comprising a respective polariser located on each face of the LCD panel.

11. A display device as claimed in claim 1, further comprising a mesh of reflective material located between the filter elements and the phosphor elements.

12. A display device as claimed in claim 1, wherein the phosphor elements comprise phosphors in crystalline form aligned to provide a predetermined plane of polarisation of light emitted therefrom.

13. A display device as claimed in claim 1, wherein the phosphor elements are applied to a non-planar surface.

14. A display device as claimed in claim 1, further comprising reflective strips embedded in a substrate on which the phosphor elements are located so as to guide light from the phosphor elements through the substrate.

15. A display device as claimed in any preceding claim, further comprising a diffuser of UV radiation located between the source or sources of UV radiation and phosphor elements.

16. A display device as claimed in any preceding claim, further comprising a reflector which reflects UV radiation towards the phosphor elements.

17. A display device as claimed in claim 16, wherein the reflector is a cold mirror.

18. A display device as claimed in claim 16, wherein the reflector is parabolic.

19. A display device as claimed in any preceding claim, wherein the source of UV radiation comprises a cold cathode UV source.

20. A display device as claimed in claim 1, wherein the phosphor elements are held between two substrates so as to avoid the use of a binder.

21. A display device substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.

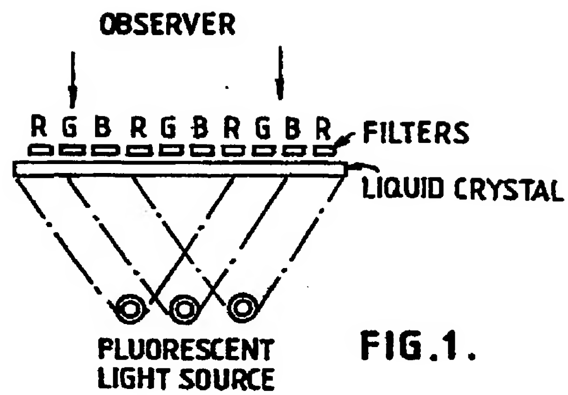


FIG.1.

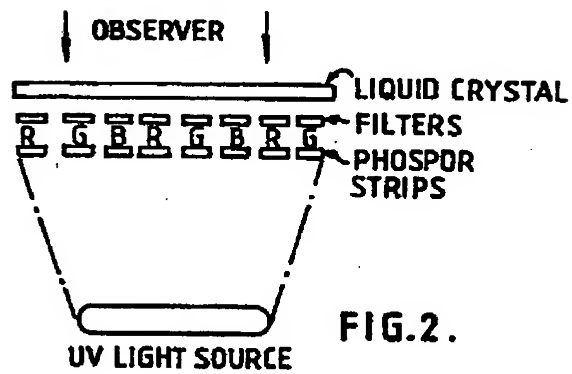


FIG.2.

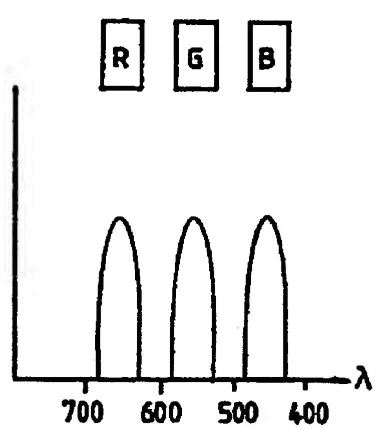


FIG.3.

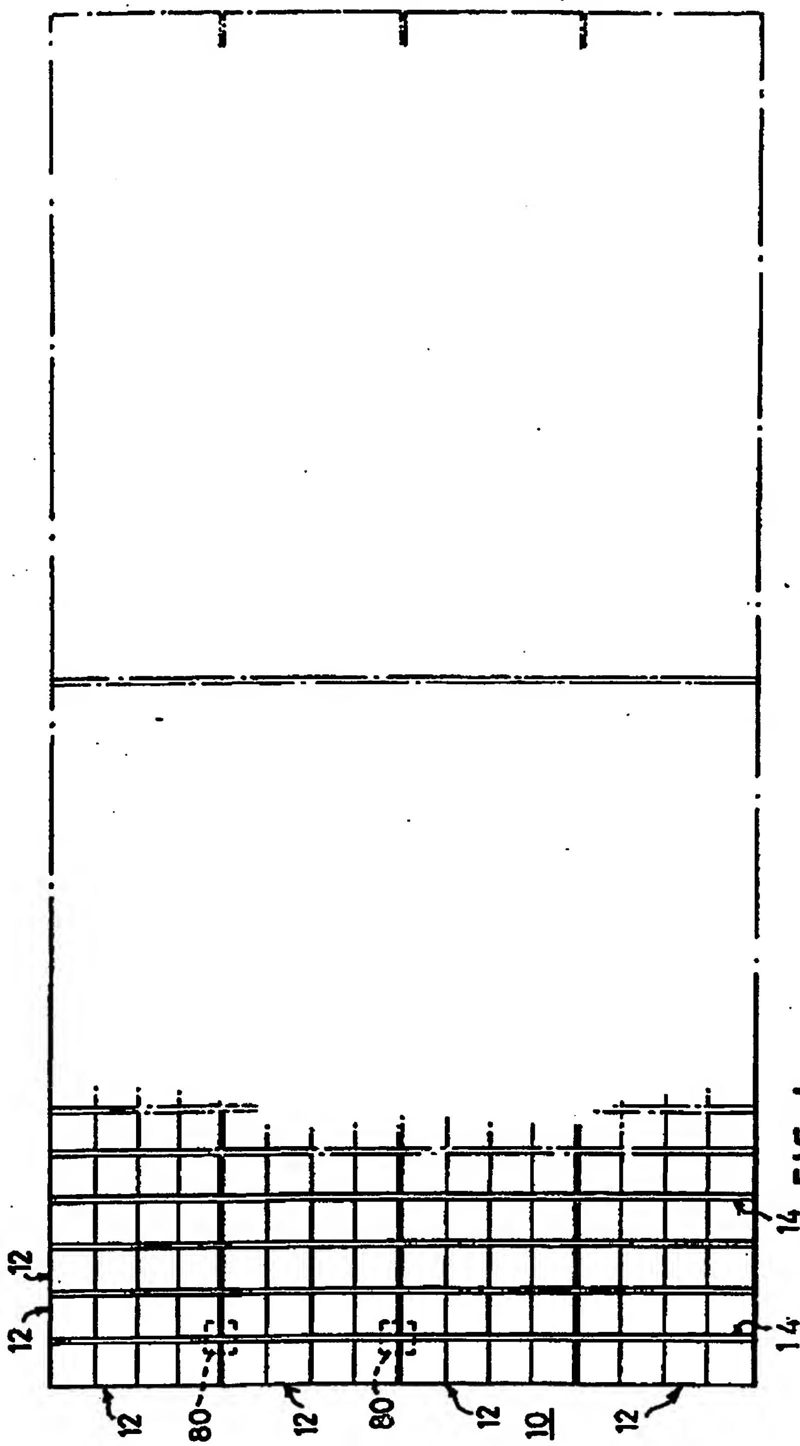


FIG. 4.

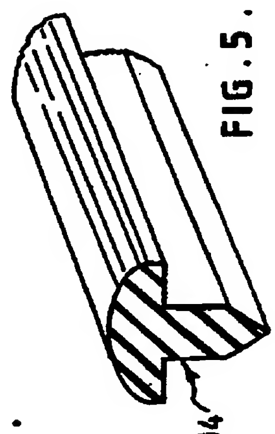


FIG. 5.

3/6

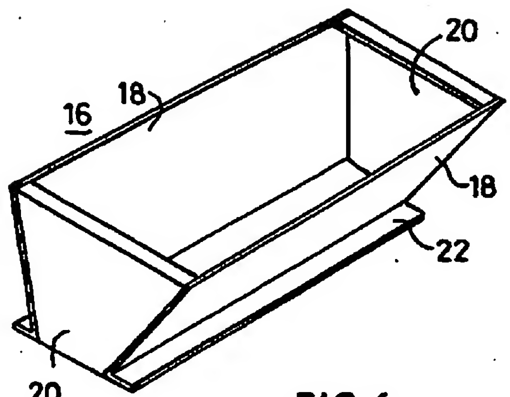


FIG 6

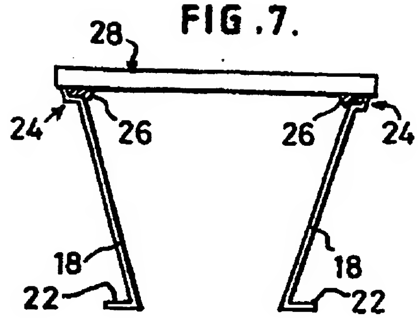


FIG .7.

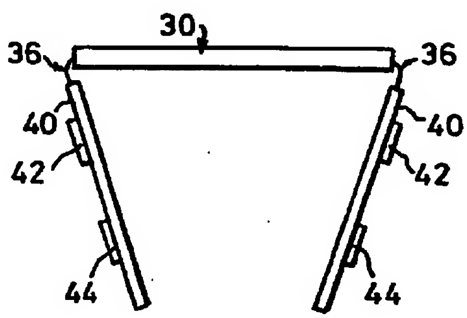


FIG .9

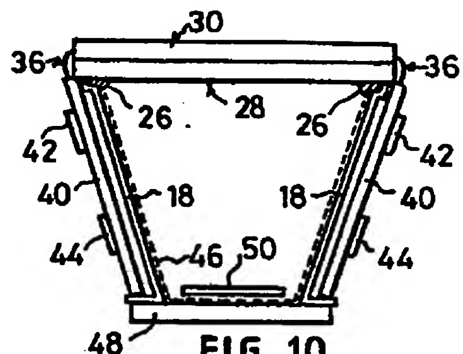


FIG .10.

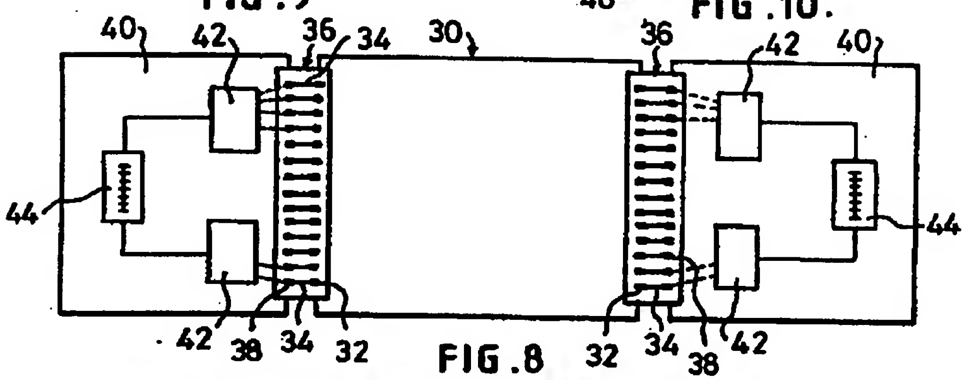


FIG .8

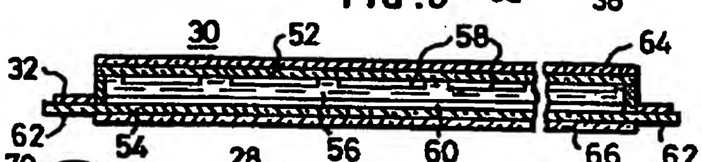


FIG .11

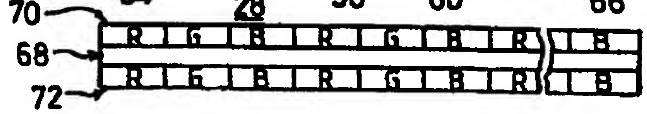


FIG.13.

SUBSTITUTE SHEET

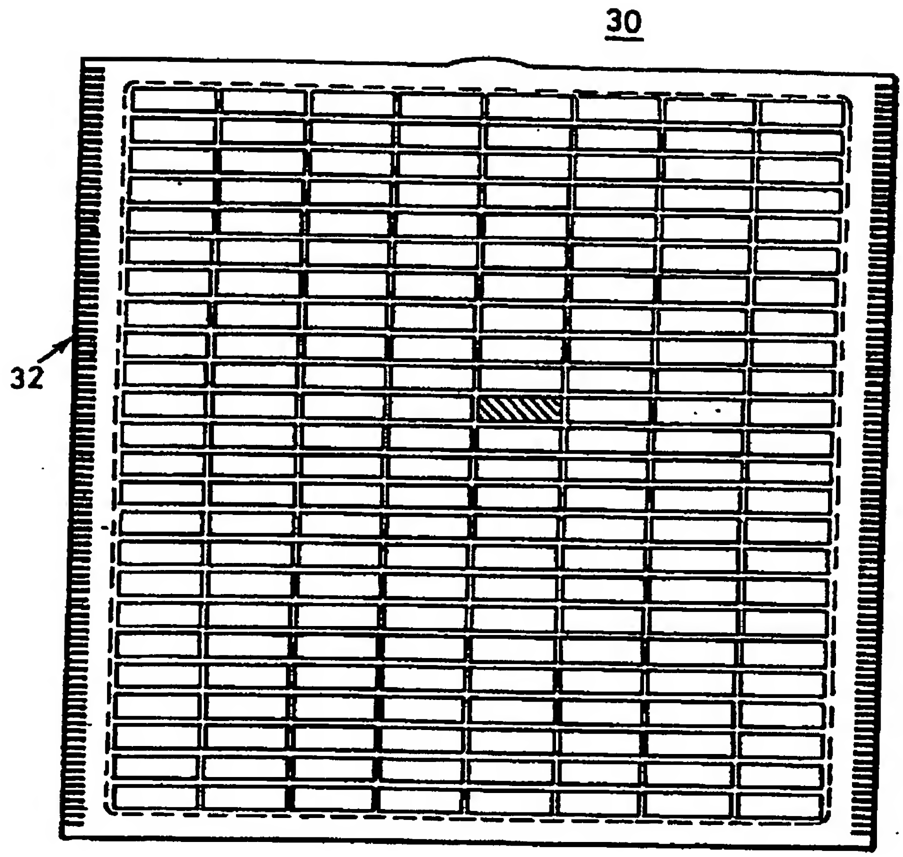


FIG.12.

FIG.15.

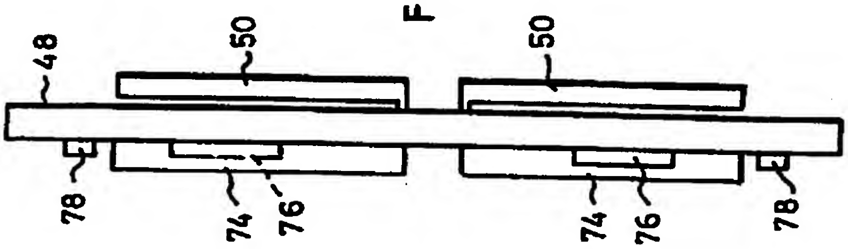
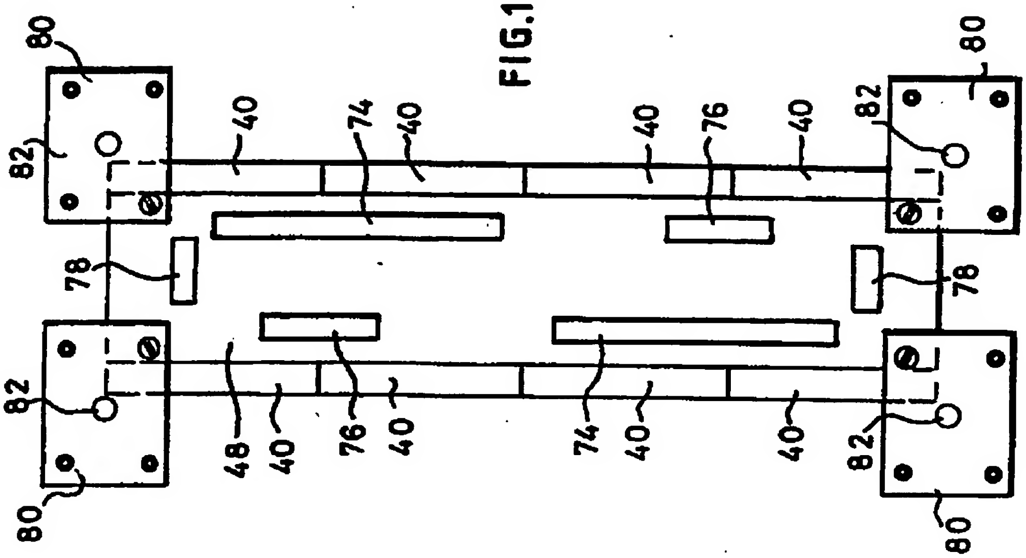


FIG.14.



SUBSTITUTE SHEET

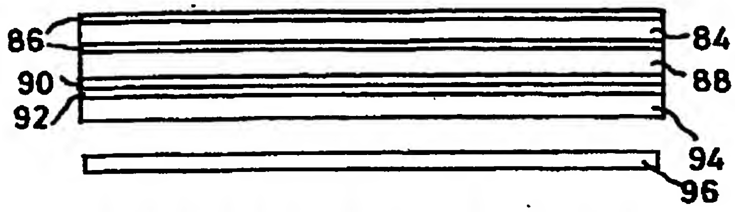


FIG.16.

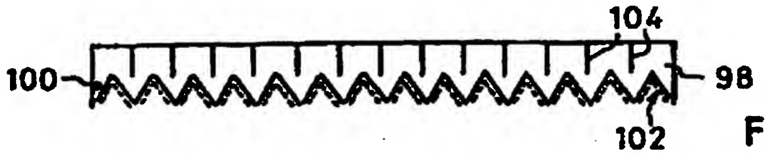


FIG.17.

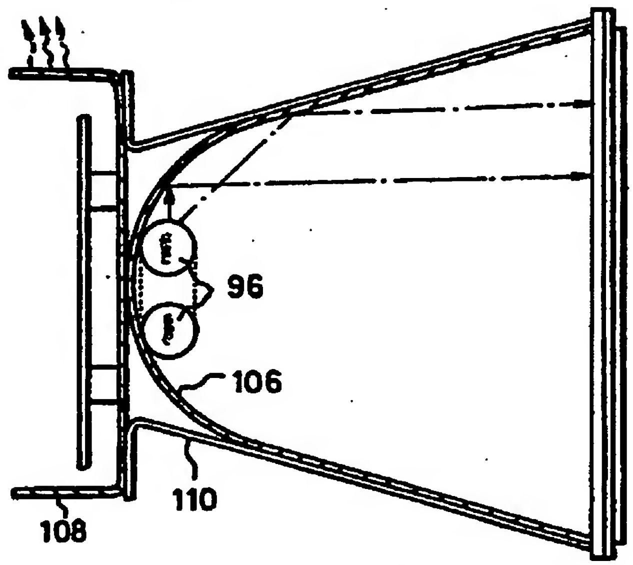


FIG.18.

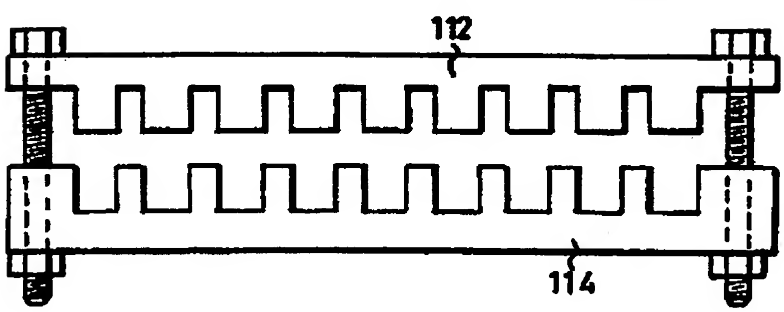


FIG.19.

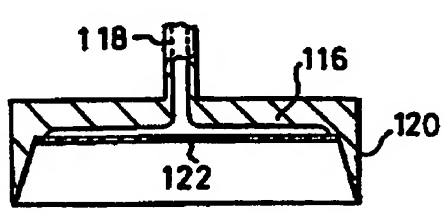


FIG. 20.

SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 90/01833

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [6]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC[5]: G 02 F 1/133, H 04 N 9/12

II. FIELDS SEARCHED

Minimum Documentation Searched [7]

Classification System	Classification Symbols
IPC[5]	G 02 F, H 04 N, G 09 F

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [8]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [9]

Category [*]	Citation of Document, [11] with indication, where appropriate, of the relevant passages [12]	Relevant to Claim No. [13]
X	GB, A, 2154355 (RICOH COMPANY LTD) 4 September 1985 see page 4, line 46 - page 5, line 45; page 6, line 45 - page 7, line 40	1-5,8-10
A		6,7,11-21
	--	
A	EP, A, 0179913 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD) 7 May 1986 see page 10, line 5 - page 11, line 21	2
	----------------------------------	

* Special categories of cited documents: [10]
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
3rd April 1991	17.05.91
International Searching Authority	**Signature of Authorized Officer**
EUROPEAN PATENT OFFICE	F.W. HECK

Form PCT/ISA/210 (second sheet) (January 1985)

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL PATENT APPLICATION NO.

GB 9001833
SA 42277

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report.
The members are as contained in the European Patent Office EDP file on 24/04/91
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
GB-A- 2154355	04-09-85	JP-A- 60149028	06-08-85
		JP-A- 60263186	26-12-85
		JP-A- 61091629	09-05-86
		JP-A- 61103185	21-05-86
		JP-A- 61103186	21-05-86
		DE-A- 3501006	07-11-85
		US-A- 4678285	07-07-87
EP-A- 0179913	07-05-86	JP-A- 60203915	15-10-85
		WO-A- 8504505	10-10-85
		US-A- 4874227	17-10-89

EPO FORM P0479

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

This Page is Inserted by IFW Indexing and Scanning Operations and is not part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- ☐ BLACK BORDERS
- ☐ IMAGE CUT OFF AT TOP, BOTTOM OR SIDES
- ☐ FADED TEXT OR DRAWING
- ☐ BLURRED OR ILLEGIBLE TEXT OR DRAWING
- ☐ SKEWED/SLANTED IMAGES
- ☐ COLOR OR BLACK AND WHITE PHOTOGRAPHS
- ☐ GRAY SCALE DOCUMENTS
- ☑ LINES OR MARKS ON ORIGINAL DOCUMENT
- ☐ REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY
- ☐ OTHER: ______________________

IMAGES ARE BEST AVAILABLE COPY.
As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.